Light and Lighting

Official Journal of the Illuminating Engineering Society.

Incorporating "The Illuminating Engineer."

32, Victoria St., London, S.W.1.

Edited by J. STEWART DOW

Telephone: ABBey 5215

Vol. XXXVI.—No. 2 February, 1943 PRICE NINEPENCE Subscription 10/6 per annum, post free

	Page
Editorial Notes ...	17
Notes and News ...	18
The Effectiveness of Lighting: its Numerical assessment ...	20
Seeing in Fog	23
Obituary, etc.	30
The Editor Replies ...	32

The Effectiveness of Lighting?

HOW to Define and How to Measure—the instructive series of papers read before the I.E.S. (see pp. 20-21), served at least to show how difficult the problem really is.

The effect is not a matter of illumination alone. Such factors as absence of glare, contrast, background and diffusion also enter in; but the exact role each plays may vary greatly with the task to be performed.

Next, we have the complexity of the eye itself so varying in individuals and so difficult to assess. In "subjective brightness" especially, we have a tantalising criterion which appears to offer a solution, but is in practice hard to apply with precision and certainty.

Such discussions should promote humility, but lend at least this encouragement, that we need not feel ashamed of being unable as yet to solve this troublesome problem. For the time being we must, it seems, rely chiefly on tests of performance—and from Mrs. Macpherson we have gained one clear cut decision, that in the study of "the rate of blinking" and kindred phenomena no salvation is to be found.

Proposed I.E.S. Social Evening

We hear that a proposal that an I.E.S. Social Evening should be held in London in the near future is now being explored. It would furnish an opportunity for members to foregather and chat--with such refreshments as can be contrived in these Spartan times. Among the events in view is a "Brains Trust," designed on lines to prove at once informative and entertaining. It is common knowledge that such affairs need a good deal of preparation and rehearsal. In the meantime, suggestions for ideas that might be worked into the programme are being invited. Will any members prepared to suggest knotty questions, entertaining problems, or amusing incidents, kindly communicate with Mr. H. C. Weston ("Inverclyde," The Avenue, Orpington, Kent), who has the matter in hand?

Black-out Accidents

The figures for road accidents in December last, the highest for any month last year, remind us that the effect of the black-out is still evident, though fatalities are less than in previous years. Four hundred and eighty-four people were killed during darkness and 296 during daylight, as compared with 668 and 356 respectively in December, 1941. The ratio night/day accidents is thus about 1.6 for 1942, as compared with 1.9 for 1941—an improvement, though it is remarkable that there should still be many *more* accidents during hours of darkness than during the day.

Forthcoming I.E.S. Meetings

March 9th. Mr. J. W. Howell on **Lighting in the Cotton Industry** *(Sessional Meeting at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.)* **5 p.m.**

March 2nd. Mr. R. O. Ackerley (President) on **"Seeing is Believing."** *(Meeting of Leicester Group in the Corporation Electricity Dept., Demonstration Theatre, New Civic Buildings, Charles Street, Leicester).* **6 p.m.**

March 3rd. Mr. W. G. Thompson on **Planning and Designing Installations.** *(Meeting of Sheffield Centre at the Central Library, Surrey Street, Sheffield.)* **6 p.m.**

March 8th. Mr. P. Hartill on **The Calculation of Illumination from Large Area Sources.** *(Meeting of Leeds Centre at the College of Technology, Cookridge Street, Leeds.)* **5 p.m.**

March 11th. Dr. Idwal Pugh on **Lighting and Health.** *(Meeting of Cardiff Centre at the Swansea Technical College.)* **3.30 p.m.**

March 26th. Dr. S. English on **Diffusing Glassware.** *(Meeting of Birmingham Centre at the Imperial Hotel, Temple Street, Birmingham.)* **6 p.m.**

March 26th. Mr. A. L. Randall on **Electric Discharge Lamps and Fluorescent Lamps.** *(Meeting of Nottingham Centre in the Lecture Theatre of the Nottingham Gas Dept., Parliament Street, Nottingham.)* **5.30 p.m.**

Looking into the Past

Reminiscences of the past, which formed part of the subject matter of Mr. Dow's recent talk to the I.E.S., Leicester Group, were again drawn upon in Mr. E. Stroud's subsequent welcome address to the Glasgow Centre. Mr. Stroud is one of those whose memories go back almost to the start of the I.E.S. in this country. He traced the development of illumination photometers and other early problems, dwelt specially on such outstanding events as the floodlighting in London during the 1931 I.C.I. conference and in connection with the Coronation in 1937, and finally cast a prophetic eye towards the future.

Fluorescent Paint Aids Passengers During Black-Out

Some applications of fluorescence have been adopted experimentally at Waterloo Station as an aid to the movement of passengers during the black-out, more particularly on the steps forming an approach to the station from the North through the Memorial Arch.

Handrails on these steps have been coated with fluorescent paint, and when this is stimulated by an 80-watt ultraviolet lamp suspended about 12 ft. to 15 ft. above the sloping rails, the effect is to make the latter very prominent and thus give confidence to passengers who might otherwise find it difficult to negotiate the steps in darkness.

An interesting feature is that the fluorescent medium on the centre handrails is embedded in vitreous enamel strips which give added permanence to the fluorescence. The earlier experiments with paint showed that this wore off very rapidly, especially on handrails, but when the fluorescent medium is embedded in vitreous enamel it stands up to the ordinary rough day-to-day wear and tear and appears to preserve its properties almost indefinitely.

Light Verse

The amusing lines reproduced below formed an unofficial appendix to the Presidential I.E.S. Address of Mr. R. O. Ackerley, which appeared in the January issue of the "Transactions." By the courtesy of the author we are able to preserve the text for the benefit of our readers.

How often in the days of peace
When batsmen manned the popping crease
The evening papers used to say
"Bad light stopped play";
But now that peace-time joys are dead
We can't afford to have it said
That due to shadow, glare, or murk
"Bad light stopped work."
Then who can put the matter right?
Can we find men to spread the light?
An echo boldly answers—"Yes,
The I.E.S."
With light of full sufficiency
And perfect suitability
We'll make each worker's output soar
And win the war.

. . . . . .

And when the days of blitz and blast
And points and coupons all are past
And reconstruction is the thing
What shall we sing?
We'll sing of lumens, polar curves,
And how soft light can calm the nerves.
Of streets by night as bright as day
Where gaily lighted fountains play.
Of light for work and light for sport
And study lamps to foster thought
Of light in shops and light in homes
And lighting terms in learned tomes.
Of light in stations, ships, and trams
And iso candle diagrams.
Of surface brightness, low or high,
And visual acuity.
Of ratios of space and height,
Reflected and transmitted light.
Of light controlling media
Diffusing, matt, or specular.
Of cut-off and efficiency
And integral photometry,
And perfect colour rendering.
Of fluorescent powdering
And stroboscopic flickering.
In fact, of almost anything
That answers to the clarion call:
"Good light for all."

The Effectiveness of Lighting: Its Numerical Assessment

(Proceedings at the I.E.S. Sessional Meeting held in London on Tuesday, February 9, 1943)

The I.E.S. meeting in London on February 9 was devoted to a somewhat unusual series of papers, all attempting to analyse the fundamental but elusive factors that really determine whether lighting is "effective" in a physiological and psychological sense.

Subjective Brightness.

Dr. W. D. Wright, in the introductory paper, returned to the problem of subjective brightness, on which he has lectured to the Society previously. He commenced by drawing attention to the great variety of factors on which "effectiveness" depends, too complex to be separately analysed and applied to the evaluation of a lighting system. Hence the tendency to rely on tests of actual performance which, however, are not always easy to arrange.

A scale of "subjective brightness," i.e., the brightness of the object as *actually seen* by an observer, which is in fact the magnitude of the visual sensation, does seem a possible means of appraisement. Subjective brightness depends upon a number of factors namely (1) photometric brightness, (2) state of adaptation of the eye, (3) colour of the object, (4) contrast with neighbouring objects, (5) presence of glare sources, (6) area of retina employed. Dr. Wright illustrated how each of these factors affects the problem, and went on to discuss various practical problems showing how "subjective brightness" does in fact often determine the judgment of an installation—not only when the performance of some task is involved but also when aesthetic effect or spectacular display is the object in view.

He recalled the suggestions made in his paper before the Society in 1941* and concluded by suggesting that illuminating engineers might become more "subjective brightness conscious" in the future, when we might come to see glare specified in "brills" just as noise is specified in "phons."

Visual Acuity

This paper led naturally to the next item, Dr. K. J. W. Craik's analysis of Visual Acuity. Dr. Craik enumerated a very formidable series of factors determining visual performance and asked whether it was possible to relate them in such a way as to enable visual performance to be predicted for any given lighting set-up. He referred for example, to the effect of glare on visual acuity, which depends so much on the brightness of the general background and other factors and is so hard to assess. One point of interest in connection with the framing of "codes" is that some processes require a much higher visual efficiency than others. One could imagine therefore some form of "visual efficiency scale." Such a scale based on subjective brightness would be difficult

* Trans. Illum. Eng. Soc. (London). 6, 23, 1941.

for the illuminating engineer to apply. One might, however, base the scale on the reciprocal of the angular width of a black or grey dot just visible against a background of a certain brightness. The angular width of a black dot which is just visible varies over a 100 : 1 range and a scale of efficiencies from 1 to 100 per cent. would cover a range of brightness from a rather dark night illumination with no moon up to summer daylight; artificial light of 1 to 50 ft.c. would be of the order of 60 to 80 per cent.

Rate of Blinking

Mrs. Sheila J. Macpherson described some patient and ingenious investigations of the conditions determining "rate of blinking"—a phenomenon which some investigators in the United States have used as a criterion of the effectiveness of a lighting installation. The experiments were conducted by the aid of a "blink-recorder" contrived by Dr. Craik. They led to the general conclusion that blinking is an irregular thing often reduced by the specific task, even though during the performance of the task it may increase progressively, or be compensated by spasms of blinking. It appears very unlikely that it could be used in practice as an indicator of good or bad lighting conditions.

Thresholds

Dr. W. S. Stiles, in the concluding contribution, gave an instructive account of work on the "thresholds," which may take various forms, such as ability just to perceive an object or to recognise a given change in brightness. Dr. Stiles presented several diagrams illustrating the influence of background brightness, etc., and described researches in which the threshold method was used.

In experiments such as those of Weston and Taylor on type-setting, an effort is made to ascertain what conditions of lighting are necessary to ensure prescribed speed and accuracy of work. Studies of industrial lighting on this basis are, however, difficult to organise. Allusion was also made to researches in connection with headlights and street lighting and to the use of "visibility meters" which, however, need to be applied with considerable discretion.

Dr. Stiles concluded that the threshold method was not likely to enable illuminating engineers to assess effectiveness of lighting on the spot, though it might prove helpful in the framing of specifications and codes.

The papers led to an interesting and keen discussion—aided by the somewhat unusual device of taking each comment in turn, so that it could be discussed jointly by all the original authors, who, incidentally, were invited to turn their batteries on each other!

Physical Society: Colour Group

The eleventh meeting of this Group, announced for March 3, includes a demonstration of a "Cellon portable Colour Matcher" and a paper, by Mr. J. Guild, on "The Significance and Limitations of the C.I.E. Standard Observer Tables."

Conference on X-ray Analysis in Industry

A conference on the above subject is to take place in Cambridge during April 9-10, 1943. Informal discussions on "Quantitative Treatment of Powder Photographs," "The Fine Structure of X-ray Diffraction," and "Line Broadening" will take place, and there will be a lecture by Professor J. D. Bernal on "Future Developments in X-ray Crystallography." An exhibition of photographs, etc., is also being arranged. Inquiries and communications should be addressed to the Secretary of the Institute of Physics, the University, Reading, Berks.

LIGHTING IN FACTORIES

MAXIMUM PRODUCTION demands correct working plane illumination.

PLANNING THE LIGHTING is a specialist's job. Our Illuminating Engineers are at your service for this purpose.

THE PERFECT INSTALLATION requires the use of the best materials and equipment. The products of our factories can be specified with confidence.

FALK, STADELMANN & Co., Ltd.

LONDON AND BRANCHES

Registered Trade Mark

EFESCA

Fluorescent (5-foot) Lamps

Owing to the need for conserving 5-ft. fluorescent lamps and ensuring their use in connection with essential work members of the E.L.M.A. have agreed to limit sales of such lamps to cases in which they are applied to new installations of an essential nature, or for the replacement of lamps in existing installations.

YES A POWERFUL ROBUST SELF-SUSTAINING WINCH

Hundreds of thousands supplied during the last 35 years to Govt. Depts., Corporations, Railways, innumerable traders, etc., etc. Will not run back. No wheels to get caught in.

Direct Drive and Ratio Type

WINCHES

Smallest wall space: side or front driving, also special types including multi-division barrels, combined horizontal and vertical operation, etc.

The London Electric Firm Croydon

Phone: Uplands 4871/2 (2 lines)

NO RATCHETS, PAWLS, SPRINGS, or GEAR WHEELS

WHERE TO BUY

(Classified List of Small Advertisements.)

We greatly regret that owing to paper restrictions and to the limits imposed on permissible advertising space, we are obliged to discontinue the insertion of small advertisements in the "Where To Buy" section of *Light and Lighting*. This item will accordingly be omitted in this and subsequent issues.

We look forward to reviving this section in the future, and in the meantime thank advertisers therein for their consistent support.

THE ILLUMINATING ENGINEERING PUBLISHING CO., LTD.

Seeing through Fog

By J. G. HOLMES

In this article we shall not be considering any new or abnormal means of fog penetration. We shall discuss only the well-established properties of fog, and it is sufficient to say that, in the author's experience, all patent methods of producing or "treating" light so as to give abnormal visibility are subject to the classical laws of optics and are equally blanketed by fog, irrespective of any of their inventor's claims. There are, of course, the exceptions of the photoelectric and photographic devices using infra-red radiation which are auxiliary to direct vision. It will be shown that the only way to improve visibility is to increase contrast between light and dark, calling for more candle-power and less scattered light and for little else. There is a practical limit to what can be done in any particular fog, this limit being set more by economic considerations than by lack of ideas in applying the well-known laws of optics.

For the purpose of this article the word "fog" will include the whole range of atmospheric conditions from a light haze to a "pea-soup" fog, and we shall indicate the different conditions of fog where required.

The effects of fog are threefold, and we shall consider them in turn. In daylight, the loss of illumination is not very serious, and the major effect is to mask distant objects so as to render them invisible. At night the loss of illumination is often serious, so that the night becomes very dark and the light from distant lamps is absorbed so strongly as to render them invisible. The third effect is the scattering of light which can be observed at night, preventing an object being seen by the aid of a light held by the observer.

Daylight Fogs

In a daylight fog we get many of the effects of threshold vision in the dark —distant objects are invisible, outlines are indefinite, colours become grey, moderate contrasts cannot be discerned, sense of movement and sense of distance become unreliable, and so on. We cannot get rid of these effects by increasing the light, because we have plenty already, and we find the only way to improve matters is to increase the contrast between what we want to see and what we do not.

Dark Objects Against the Sky.

How does the lack of contrast arise? The objects at which we are looking are unchanged and the light falls evenly upon them. Consider for a moment a dark building which we normally see silhouetted against an overcast sky and which in fog appears only as an indefinite shape, without depth and without any of the recognisable features which give it reality. The foggy background which is behind and around the building may be just as bright as the overcast sky, but we cannot see the building in clear silhouette because between our eyes and the dark walls is a column of atmosphere full of minute particles, each of which is scattering light towards us. What we see, therefore, is the light scattered by this column of atmosphere between ourselves and the building, surrounded by light scattered from a virtually infinite column, extending to the horizon beyond the building. Obviously, this scattered light will be featureless and grey, and thus the building is masked by a luminous grey blanket which, as the fog gets thicker, eventually becomes so nearly the same brightness as the surround that the difference cannot be detected and the building is invisible. If the building is white, the contrast against the surround will be less, and it will become invisible for a fog of less density than that necessary to obscure a black building, although both experiment and calculation show that the difference is not usually very great.

It is possible to measure the difference in brightness of the foggy background or infinite column and of the building or comparatively short column of atmosphere, and the results are very interesting. It is found, for instance, that an object of usual size, say 1° wide (or 1 ft. at 60 ft.), can just be seen if the brightness of the short column of atmosphere is about 98 per cent. of that of the infinite column, giving what is known as a 2 per cent. contrast, although various experimenters have obtained figures varying between 96 per cent. and 99 per cent. If we move nearer to the building, the difference or contrast will be more pronounced, according to a fairly simple mathematical relation, with which we need not trouble now, and a measurement made under these conditions will be more accurate than a measurement at the threshold of vision. Either measurement will enable us to

calculate the optical properties of the fog and to deduce its other characteristics.

Dark Objects Against Dark Background

Another and more usual effect of fog is to make it difficult or impossible to discern a dark object against a dark background, and the result of this is to make the building apparently featureless. The contrast between, say, an unlighted window and the wall of the building is low in clear weather, and when a masking brightness is added to both, the window becomes invisible. We may be able to see a nearer dark object silhouetted against a distant dark object because of the different brightnesses of the two "columns" of foggy atmosphere, but this contrast becomes negligible when the two objects are at almost the same distance. In these cases the use of white paint gives increased contrast and renders the outlines of a dark object almost as readily seen as if it were silhouetted against the sky.

A Light Source Against a Dark Background

Let us suppose a lamp is lit in one of the windows of our building. We know that the apparent intensity of the lamp will be less than if the air were clear, and it so happens that measurements show that, at the distance at which the building can just be seen, the apparent intensity is reduced to about 2 per cent. of the real intensity, irrespective of the density of the fog. This introduces the idea of "transmission factor," and what we have just said may be restated, that the transmission factor of any fog is 2 per cent. for the daylight visual range or, to put it into symbols:—

$$(T_1)^d = 0.02 \quad \text{.....(1a)}$$

or in logarithmic form:—

$$d \,.\, \log T_1 = -1.699 \quad \text{.....(1b)}$$

where d is the daylight visual range and T_1 is the transmission factor for unit distance.

Equation (1) was derived by Koschmieder and is a particular case of his more general theorem that the contrast between a black object at a distance x and the sky is equal to the transmission factor of the atmosphere for the distance x. It follows that the reduction of contrast due to fog can be calculated from a knowledge of the characteristics of the fog, and this has been done in "Visibility in Meteorology," by W. E. K. Middleton (University of Toronto Press).

It is general experience that a lighted window can be seen at a greater distance than a building in a daylight fog. This is quite consistent with the above simple mathematics, because a light is often so bright as to be easily visible when reduced to 2 per cent. of its original intensity, so that it is still clearly seen when the building has disappeared. Another example of this is seen by the side lights or headlights of a car approaching through a fog in daylight. The necessary intensity of the light can be calculated, as shown in the next section.

International Visibility Code

Before we leave daylight fog it is perhaps appropriate to refer to the International Visibility Code, which enables universal records to be kept at meteorological stations. A series of standard distances has been agreed upon and each is represented by one of the code digits 0 to 9. Table 1 gives the essential figures for the code and the atmospheric transmission calculated from Koschmieder's relation.

It has been shown that the ways of improving visibility in a daytime fog are to increase the contrast, as by stripes of white paint on kerbs, or to provide a

Table I

Code Number	Weather	Maximum daylight visual range	Maximum transmission per kilometre	Maximum transmission per mile	Maximum transmission per nautical mile
0	Dense fog	50 metres	—	—	—
1	Thick fog	200	—	—	—
2	Moderate fog	500	0.04%	0.0003%	0.00005%
3	Light fog	1,000	2 %	0.19 %	0.07 %
4	Thin	2 kilometres	14 %	4.4 %	2.7 %
5	Haze	4	37 %	21 %	16 %
6	Light haze	10	68 %	53 %	48 %
7	Clear	20	82 %	73 %	70 %
8	Very clear	50	93 %	88 %	87 %
9	Exceptionally clear	over 50	over 93%	over 88%	over 87%

bright light, which is, of course, only another way of increasing contrast.

Night Fog

The two effects of absorption and scattering become more important at night, when we rarely have sufficient artificial light, even in clear weather in peace-time, and we shall require another picture by which to illustrate the factors involved.

Absorption of Light in Fog

The absorption of light is well illustrated by a street lamp which rapidly becomes invisible as we walk away from it in fog. The rays from the lamp may be visualised as radiating directly through the fog and passing in straight lines between the fog particles until each ray has fallen upon a particle and no direct light is left. The free path of the rays will depend on the size and number of the particles and, as any given number of particles will absorb a fixed proportion of the radiation falling upon them, it is a simple mathematical exercise to show that the transmission factor is an exponential function of the form: $T_x = 10^{-kx}$ where T_x is the transmission factor for a distance x, and k is the extinction coefficient of the fog, such that the transmission factor for unit distance is $T_1 = 10^{-k}$. As either x or k increases the transmission will decrease and the light will become less conspicuous. It has been found that a light equivalent to 0.5 candle at a distance of one mile in perfectly clear weather may be regarded as conspicuous (i.e., readily seen) on a dark night, and so we can calculate the range of the street lamp by finding at what distance its apparent intensity falls to this value. This will involve a short mathematical interlude.

If the illumination produced on the observer at a distance x (ft.) is E (ft.c.), the apparent intensity of the light I (candles) is given by

$$I = E.x^2 \quad \ldots\ldots(2)$$

The actual intensity I_o of the light is related to the apparent intensity by the transmission factor of the atmosphere for the distance x, as follows:—

$$I = I_o . T_x = I_o . 10^{-kx} = I_o . T_1^x \quad \ldots(3)$$

The maximum range at which the light can be seen is therefore given by

$$I_o . T_1^x = E_1 . x^2 \quad \ldots\ldots(4)$$

which is known as Allard's relation. It holds equally well for foot or mile units if the appropriate values are taken. The limiting illumination E_1 on the observer is that given by 0.5 candle at one mile or

$$E_1 = 0.5 / (5280)^2 = 1.8 \times 10^{-8}$$

foot-candles and the range of the light can be calculated from the equation:—

$$I_o . T_1^x = (1.8 \times 10^{-8}) x^2 \quad \ldots\ldots(5)$$

which can be put into logarithmic form:

$$x . \log T_1 = -7.75 + (2 \log x - \log I_o)$$

for a one foot unit ..... (6a)

or

$$x . \log T_1 = -0.301 + (2 \log x - \log I_o)$$

for a one mile unit ..... (6b)

A fundamental difference between Koschmieder's relation (Equation 1b) for daylight vision and Allard's relation (Equations 6) lies in the operation of the inverse square law on small sources of light as seen under night-time conditions.

It is appropriate here to include a similar calculation for the visibility of lights in a daylight fog. If the daylight illumination is E′ (ft-c.) the value for E_1 (ft.c.) to be taken in Equation (4) above is approximately

$$E_1 = 10^{-7} \times \sqrt{E'} \quad \ldots\ldots(7a)$$

This relates to threshold visibility of a light by foveal vision and makes no allowance for the need of finding the direction of the light. For the same degree of conspicuity in daytime as 0.5 mile candle at night, the value for E_1 should be approximately

$$E_1 = 3 \times 10^{-6} \times \sqrt{E'} \quad \ldots\ldots(7b)$$

If this value of E_1 is inserted in Equation (4) and one-foot units are employed for T_1 and x, the value of I_o for conspicuous vision in a daylight fog may be calculated.

It is comparatively simple to measure the transmission factor by the diminution of brightness of an illuminated screen, and this has become a routine part of outdoor photometry since it was realised among photometrists a few years ago that T_1 rarely exceeds 80 per cent. per mile in this country, and is frequently as low as 10 per cent. per mile at night. Other methods of measuring the absorptive properties of fogs are by employing an extinction meter and by estimating the distance at which a light of known intensity is obscured, but both these depend on the conspicuity "constant" E_1 and are subject to considerable variation between observers.

Returning to our street lamp, it is common experience that fog is very

faintly illuminated by a distant and invisible lamp, and that as we approach the lamp the general illumination increases slightly, until quite suddenly we see the light source itself surrounded by a comparatively small patch of brightly scattering fog. In a haze or light fog this halo does not appear at the limiting range, whereas in the densest fogs we may see the patch of scattered light just before seeing the light source itself. The difference is due almost entirely to the operation of the inverse square law for the widely differing scales of distance for the two conditions.

There is also a psychological effect which appears with flickering lights and, for example, a paraffin flare which is flickering between 20 candles and 100 candles has been stated to be somewhat more conspicuous than a steady light of 100 candles. There has been no conclusive evidence of this so far as the author is aware, but it appears to be probable.

It is common experience that a light near the threshold of vision is more clearly seen at night when looking slightly to one side of it rather than directly at it, and this is equally true in fog, where the light may be surrounded by a halo. It may also be pointed out that when the daylight illumination is low (0.1 ft.c. or less) the perception of contrast, and even of outline, is improved by looking slightly to one side of the object, and it is often possible to recognise a distant object in a fog at dusk or dawn under conditions such that the object can scarcely be seen at all when looking directly at it.

The range at which a light can be seen in a given fog depends primarily on its intensity in the direction of the observer, and Table II. sets out the distances at which three light sources of different intensities can be seen in various densities of fog at night.

Table II

Code No.	Maximum range at night		
	10 candles	1,000 candles	1,000,000 candles
0	0.07 mile (120 yds.)	0.10 mile (180 yds.)	0.15 mile (260 yds.)
1	0.21	0.32	0.50
2	0.4	0.7	1.2
3	0.7	1.3	2.2
4	1.0	2.1	3.8
5	1.5	3.5	7
6	2.3	7	15
7	3.1	10	26
8	4	17	55
9	over 4	over 17	over 55

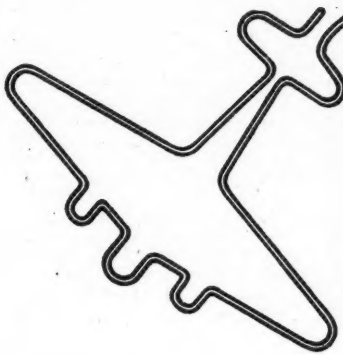
Fig. 1 shows the intensity necessary for conspicuous vision of a light at different distances for the various densities of fog at night.

Scattering of Light in Fog

Turning now to the question of seeing an object in fog by the aid of a light, we can visualise a pedestrian approaching a lamp near the observer. The pedestrian will, of course, be able to see the lamp before we see him, and we have already discussed the conditions by which he sees the lamp. We see the pedestrian under conditions somewhat similar to those of a daylight fog, requiring a contrast between the brightness of the fog background illuminated by the lamp and that of the form of the pedestrian also illuminated by the lamp. There is, however, the difference that daylight visibility almost invariably depends on the contrast between a dark object and the light fog background, whereas at night the contrast may be between the background and the dark form of the pedestrian or between the background and a light article, such as a newspaper or handkerchief which he is carrying and which is illuminated by the lamp. The former case is very similar to daylight conditions and we need not discuss it further. The latter case is peculiar to night conditions, and it may, perhaps, be pointed out that whereas a black object is easier to see than a white object in a daylight fog, the reverse is true in a night fog. The least visible object in a daylight fog is a white or light grey and that in a night fog is a dark grey.

It is obvious that the larger the white area or the higher its reflection factor the better we shall see it at night. It is also obvious that if we double the intensity of the lamp we shall increase both the background brightness and the brightness of the white area, without any increase in contrast. If the intensity of the lamp is increased unduly, the background brightness becomes high enough to cause glare and after-images, so that the sensitivity of the eye is decreased. The background brightness is due to back-reflection of the light from the lamp, and may be reduced by screening the light so as to cast a shadow through which we can look, or by moving sideways from the lamp so that we are looking through fog which is illuminated less. These two ways of

POWER FOR ARMS PRODUCTION MUST NEVER FAIL

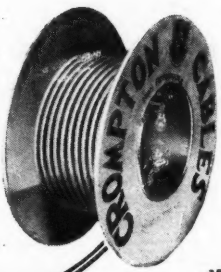


SPECIFY

CROMPTON

V.I.R.

CABLE



CROMPTON PARKINSON LIMITED
ELECTRA HOUSE
VICTORIA EMBANKMENT LONDON W.C.2
Temple Bar 5911 *Crompark, Estrand, London*

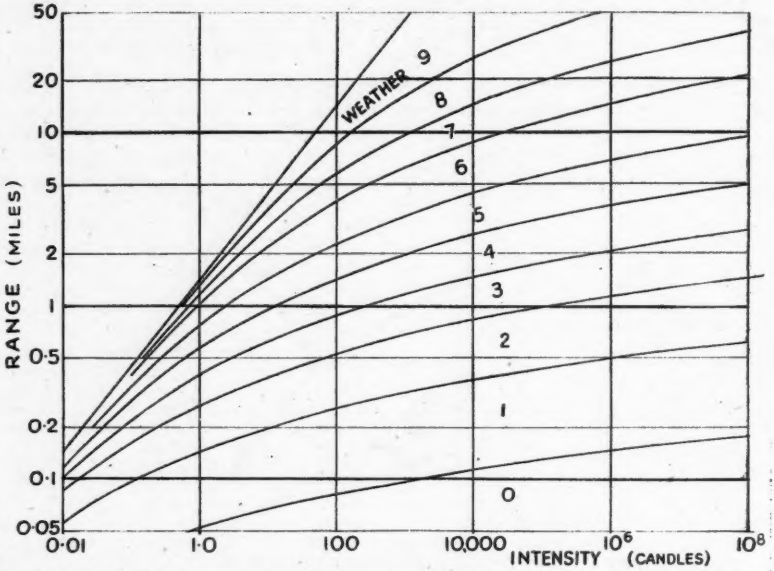


Fig. I shows the intensity necessary for conspicuous vision of a light at different distances for the various densities of fog at night.

increasing the contrast are commonly employed in a well-designed and correctly mounted motor-vehicle fog lamp, as was pointed out by Mr. M. G. Bennett in his article on the subject of atmospheric transmission in the "Illuminating Engineer" for March, 1933.

The distance at which a light can be seen is always greater than the distance at which objects may be seen by its aid. The calculation of the latter has been carried out by Dr. W. M. Hampton (Proc. Phys. Soc., p. 663; **45,** Sept., 1933), and from his theory it may be deduced that the brightness of the foggy atmosphere illuminated by an unscreened lamp is given by $k\ I_0/3.5\delta$ candles per sq. foot where k and I have the same meaning as before and δ is the distance in feet between the lamp and the point of observation. This gives us a value for the background brightness and we can put this into Equation (7b) to obtain a value for the constant E_1. The conspicuity equation must take account of the double path of the light from lamp to object and back to the observer, and it may be shown that the following expression is required:

$$a.r.I_o.T_1^{2x} = \pi.E_1.x^1 \ldots\ldots\ldots\ldots (8)$$

where a is the area of the object and r is its reflection factor. The figures in Table III. have been calculated from this equation for fogs of three densities in which a 100 c.p. light can be seen at 100 ft., 500 ft., and 1,000 ft. respectively and for an object 18 in. by 18 in. of 80 per cent. reflection factor:

Table III

Distance at which a 100 c.p. light can be seen	100 ft.	500 ft.	1,000 ft.
Intensity of light near the observer	Range at which the object can be seen by an observer at 3 ft. from the light		
10 candles	20.2 ft.	54 ft.	79 ft.
100	22.9	66	97
1,000	26.1	76	118

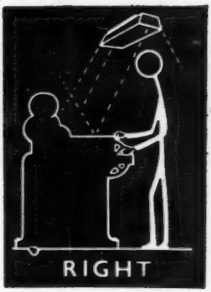
Observations have confirmed that these figures are of the right order, but the theory is necessarily based on a number of approximations and cannot be regarded as exact.

Colour

The subject of colour in fog has been discussed in some detail in Mr. Bennett's paper and in several other papers in the same journal, but it may be of

BTH LIGHT-CONDITIONING takes account of every lighting need.

Specular Reflection — produces the direct or diffused image of a light source on the work. Machined surfaces, such as steel, brass and aluminium in the plant, may act as direct reflectors contributing to this problem. It can be reduced by increasing the general level of illumination with low-brightness light sources, or changing mounting height and position of offending units.



When a BTH Lighting Engineer is called in to advise on the lighting of a factory, he does not merely consider the *amount* of light required. He studies the individual needs of every process and every operative. He notes exactly where each unit should be placed in relation to the machine or process it is intended to light in order to avoid shadows and glitter. And, in particular, he will try to arrange the lighting in such a way as to simplify complicated processes by the elimination of non-productive movements necessitated in the past by inadequate illumination.

A common defect and its remedy are shown in the illustrations. Let BTH Lighting Engineers help you to plan efficient lighting for production and welfare.

MAZDA Lamps
with MAZDALUX Equipment

M3966

B T H for all Electrical Plant and Equipment

THE BRITISH THOMSON-HOUSTON CO., LTD., CROWN HOUSE, ALDWYCH, LONDON, W.C.2.

SAVE ELECTRICITY — by all means

interest to summarise the conclusions. A thin fog scatters or absorbs the short wavelength light, violet and blue, more than the long wavelength light, yellow and red, but a thick fog shows practically no selective absorption or scattering. Thus a distant dark object looks blue and a distant white light looks yellow in hazy weather, whereas thick weather has no colouring effect. The yellowness of the general daylight illumination in a "pea-soup" fog is due to the light having passed through a great thickness of fog containing absorbing particles, but it will always be found that the illumination in a shallow ground mist is white. There is in general no advantage to be gained by placing a yellow or amber coloured filter over a light in order either to see it or to see by it, because the very slight gain in relative visibility is more than offset by the loss in intensity due to absorption in the filter. In the same way there is nothing to be gained by colouring objects which are required to be seen in fog, for the loss in reflection factor will decrease their contrast and the colour will be so masked by the intervening column of fog so that its distinctive character is lost.

In conclusion, acknowledgment must be made to many in this country and abroad who have studied the problems of atmospheric scattering and on whose work the generalised statements in this article have been based. The author's thanks are due also to Dr. W. M. Hampton for his interest in this article and to the directors of Messrs. Chance Brothers, Ltd., for permission to publish it. Research has solved many of the problems of vision of distant lights in daylght and after dark, but the question of seeing an object by the aid of a light still calls for both experimental and mathematical investigation before the effects of the various factors can be assessed.

Obituary

Lord Hirst of Witton

Lord Hirst, who passed away on January 22 at the age of seventy-nine years, was one of the founders of the General Electric Co., Ltd., fifty years ago. He became managing director in 1900 and chairman in 1910—a great advance from his initial venture in "a little electrical shop" in 1886. From this small venture sprang the G.E.C. Apart from his relationship to this great concern, for which he did so much, Lord Hirst had wide interests. He served as President of the Federation of British Industries, the Institute of Fuel, the Association of Technical Institutions, the British Electrical Development Association, and other bodies, and was one of the very few honorary members of the Institution of Electrical Engineers. In his youth he was a good athlete, and he retained through life his interest in sport and his love of horses—he attained considerable success on the Turf. To his dynamic vigour the rapid growth of the G.E.C. was largely due. It was characteristic that he united with great shrewdness in business a profound belief in the value of research in industry—a belief illustrated in the founding of the company's research laboratories at Wembley, amongst the finest in the world.

H. J. Couzens

We regret to record the death on February 15 of Mr. H. J. Couzens, of H. J. Couzens, Ltd., who recently joined the I.E.S. and was attached to the Sheffield Centre.

Thomas Dickie Colquhoun

We learn with regret of the loss of the second son (Thomas Dickie Colquhoun) of Mr. J. F. Colquhoun, a Fellow of the I.E.S. and public lighting engineer of Sheffield. Mr. Colquhoun's son, who was training as a pilot for the R.A.F. in Canada, recently lost his life in a flying accident. Before joining the Services he was technical assistant to the General Electric Co., Ltd., in Sheffield.

CRYSELCO

CRYSELCO LIMITED BEDFORD

FURSE LIGHTING

& Dimmer Equipment

for

STAGES, CINEMAS, BALLROOMS, EXHIBITIONS, FLOODLIGHTING DISPLAYS

AND ALL COLOUR & DECORATIVE LIGHTING

We are actual Manufacturing Specialists, and invite enquiries for complete schemes

W. J. FURSE & CO. LTD.

NOTTINGHAM: 65 Traffic St. Tel.: 8213 (5 lines)
LONDON: 9 Carteret Street, Westminster, S.W.1
MANCHESTER: 20 Mount Street.
Tel.: Blackfriars 5014-5

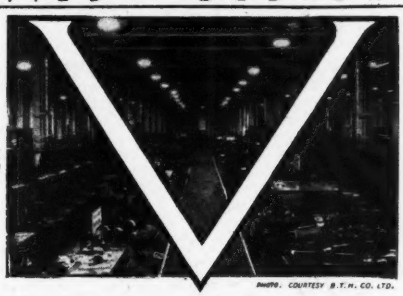


PHOTO. COURTESY B.T.H. CO. LTD.

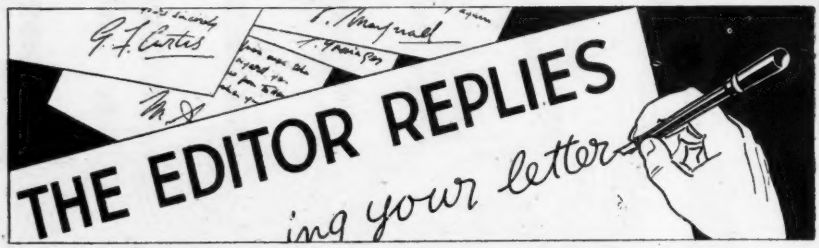
VITREOSIL *in* FACTORY LIGHTING

Improvements in factory lighting have been accelerated by the war. One of the newest developments in lighting, the super-pressure Mercury Vapour Burner has only been made possible by reason of the well-known heat resistance of fused silica. Transparent VITREOSIL, pure fused silica, has been manufactured for over 30 years and is used in these new lamps of high efficiency.

THE *Sole Manufacturers:* LTD.

THERMAL SYNDICATE

Head Office and Works: Wallsend, Northumberland.
London Depot: 12-14, Old Pye Street, Westminster, S.W.1.



The remarks in our last issue on **"Science and the Nation"** have drawn a letter from *Scientist*, of Trinity College, Cambridge, who remarks that it leads to inferences in the minds of many scientists to-day. He draws attention to the apparent existence of a "dark space" between the work of the scientist and of the advisory or administrative body which directs it. In "the exalted circle where history is made," he contends there is need for the introduction not only of the scientific outlook but of *the scientists themselves*! On the outcome of such questions as these will depend the kind of service which such societies as the I.E.S. will be able to give to the community in the future.

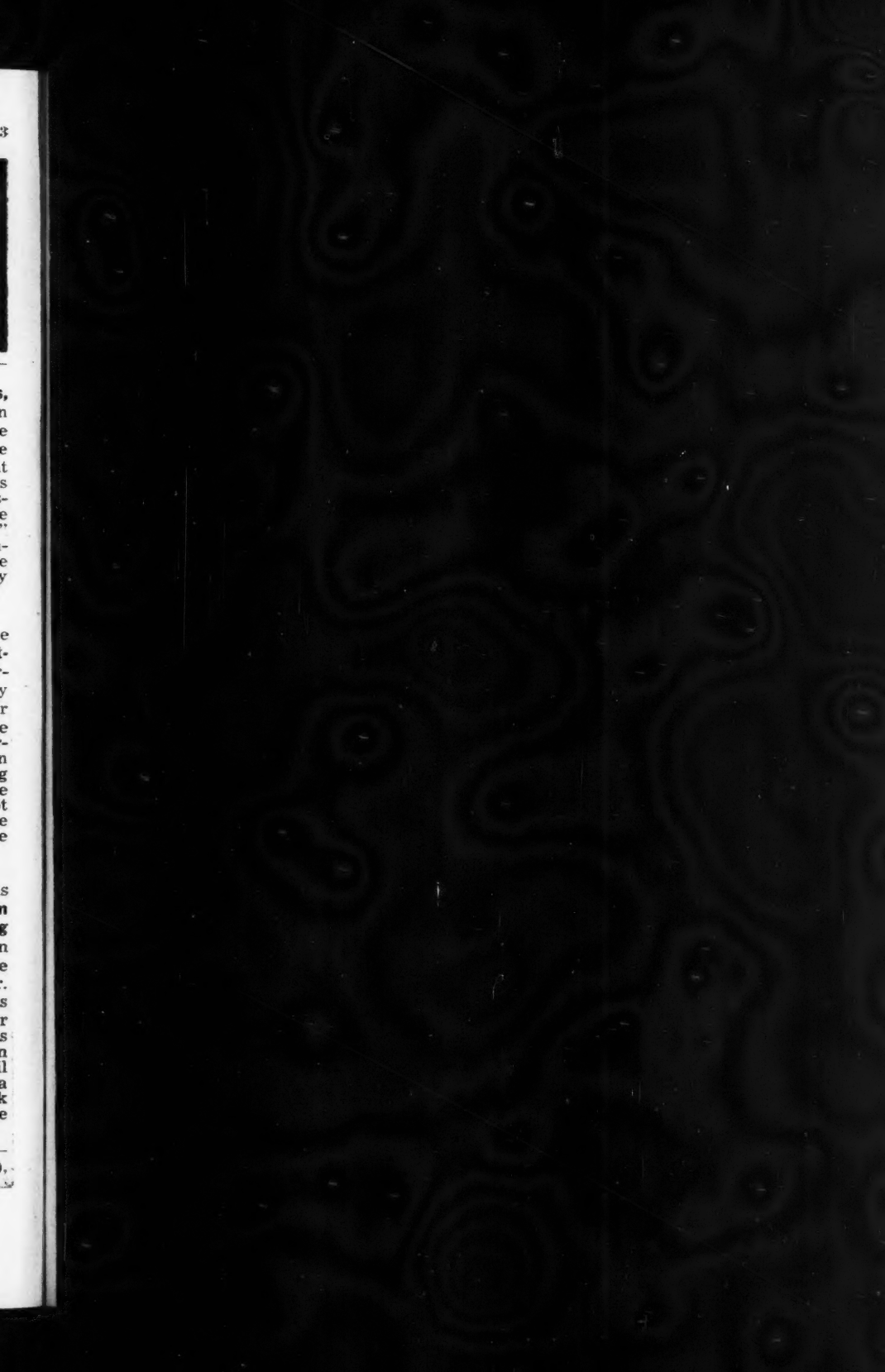
Lt.-Colonel Kenelm Edgecumbe has expressed his interest in the **correcting factors for photoelectric photometers** mentioned in our last issue and gives the following corrections which are applied to the auto-photometer for various light sources:—

Light source.	Constant. Multiply reading by:
Vacuum and gas-filled lamps ...	Direct
Sodium discharge	1.43
Mercury discharge	1.17
Incandescent gas	1.08
Daylight lamps	0.97
Natural daylight	0.80
Miners' flame lamp	0.9
Fluorescent tubular lamp (5 ft.)	0.95

These seem to bear a general resemblance to those appearing in *The I.E.S. Lighting Review* (Australia). Sodium discharge lamps have again the highest factor. Values for extreme colorations (e.g., red and blue discharge lamps) are not given, but it may be assumed that they would be of the same order as those quoted last month.

We have before us a copy of the Quarterly News Letter of the Pedestrians Association, in which a strong plea is made for the **lighting of crossings,** which, truly enough, are considered in present circumstances often to give only a false sense of security. At the present moment this problem might well be reconsidered. Some aid of this kind would be in line with the suggestions in the now familiar "War-time Street Lighting and Aids to Movement," I.E.S. report,* wherein the use of "controlled local brightness" to alleviate the dangers of the black-out was strongly emphasised.

My attention has been drawn to the reports in the Press that **brighter lighting in trains and buses** is to be permitted. A contributor to the "Daily Express" has found that in a number of London buses 1 ft.-c. can now be obtained for reading purposes—certainly a departure from the condition prescribed in the original Lighting Order of 1939, which required that "the illumination from any lamp does not exceed 0.006 ft.-c. at any point in the vehicle at a distance of 4 ft. from the lamp."

An interesting appointment in the gas industry is that of **Mr. C. A. Masterman** as **Convener to the Post War Planning Committee** of the British Gas Federation—an appointment which recently became vacant owing to the death of Mr. Stephen Lacey. Mr. Masterman was for many years chief technical officer at the Gas Light and Coke Company's Research Laboratories at Watson House. He has served on the Council of the I.E.S., of which he has been a member since 1928, and in whose work he took a great interest during the period preceding the war.

* Trans Illum. Eng. Soc. (London), February, 1941, p. 17.